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TESTS OF PROPELLER-SPEED COOLING BLOWERS

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INTRODUCTION

The solution of the cooling difficulties of air-cooled engine installations is usually effected by increasing the air flow through the engine baffles. The air flow can be increased either by boosting the pressures in front of the engine by a blower or by reducing the pressure behind the engine by cowl flaps. Numerous results of cowl-flap investigations are available, but the design methods and operational characteristics of cooling blowers have received little attention.

A few tests of cooling blowers for air-cooled engine installations have been made in the NACA full-scale tunnel incidental to a more general engine-cooling investigation; the results are briefly summarized to indicate the possible usefulness of blowers of rather simple construction. The methods used in the blower design and the operating characteristics of the blowers over a range of flight speeds and altitudes are not given but will be presented later.

The axial-flow blowers were attached to the propeller and turned at propeller speed. Operation of the blower at propeller speed, while severely limiting the pressure boost available, greatly increases the simplification of the installation and avoids the use of gearing for the drive. Two different blowers were tested, one of which was attached to a spinner and the other to a "dishpan." Tests were made for simulated climbing and high-speed flight.

APPARATUS AND TESTS

The full-scale wind tunnel, equipment, and methods of operation are described in reference 1. A photograph showing the engine installation on which the blowers were mounted is shown in figure 1. The installation includes

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a Pratt & Whitney R-1830-43 engine with 16:9 gearing, an NACA cowling having a nose inlet diameter of 36 inches, and a Hamilton Standard constant-speed propeller.

On the spinner blower (fig. 2) 27 wooden blower blades were attached at the rear of a sheet-metal spinner bolted to the propeller hub. The dimensions of the spinner and blower blades are shown in figure 3. The wooden blower blades were attached by a single bolt to a wooden ring that formed the rear bulkhead of the spinner. Blade-angle adjustment was obtained by rotating around the bolt. The dishpan blower (figs. 4 and 5) was constructed in simpler fashion with 36 blower blades of twisted sheet iron welded to the outer rim of the dishpan. The mean camber line of these blades was the same as that of the wooden blades of the spinner blower (fig. 6). When the blowers were installed on the cowling (fig. 7), the clearance around the tip of the blower blades varied from 1/8 to 5/16 inch around the periphery of the cowl. Smaller clearances, which would have been desirable, were impossible because of the cowling dissymmetry.

A diffuser passage was constructed in the cowling from the nose opening to just ahead of the cylinders (figs. 3 and 6). Fixed stator vanes located behind the rotor at the inlet of the diffuser were used with the spinner blower. For the first test with the dishpan blower no stator vanes were used; one test was made, however, in which three vanes were located at the top of the engine (fig. 8).

Tests were made of the spinner blower at values of V/nD corresponding to high-speed and climb conditions with the angle of attack and the outlet flaps adjusted in each case to simulate these flight conditions. The dishpan blower was tested only in the simulated climb condition. The pressures on the front of the engine were measured by means of five open-end tubes located at the inlets of the head and barrel baffles on each cylinder.

RESULTS AND DISCUSSION

The effectiveness of the blowers in increasing the total pressure at the front of the engines is shown in figures 9, 10, and 11 by comparing the blower results with those of the original NACA cowling installation. The total pressures H are given in terms of the stream dynamic pressure q_o.

At the climb angle of attack the pressure distribution in front of an engine installation with a conventional NACA cowling and an uncuffed propeller is unsymmetrical (fig. 9) and the total pressures at the top of the engine are considerably lower than those at the bottom. This condition is aggravated by the blocking effect of the propeller governor in front of cylinder 1 and the top cylinders frequently run hot. One of the main purposes of the blower study is to investigate methods of increasing the pressure at the top of the engine, and from figure 9 it will be noted that the front pressures were increased from 20 to 40 percent for top cylinders 1, 2, 13, and 14. The pressures at the bottom of the engine were increased as much as 50 percent by the blower operation. The pressure drop across the engine was larger by about the same increment as the front pressures were increased because the pressures behind the engine were not largely influenced by the blower operation.

The simpler dishpan blower without stator vanes was almost as effective as the spinner blower and provided about the same front pressures except for cylinders 3, 4, and 5. Without the stator vanes behind the dishpan blower it was expected that a swirl would be set up by blower operation and vanes were added ahead of cylinder 1 for the purpose of converting locally the swirl velocities into pressure head. Results obtained by adding the stator vanes on either side of the propeller governor (fig. 8) are shown in figure 12 and it will be noted that the total pressure in front of cylinder 1 was increased from $0.73q_o$ to $1q_o$ in this way. The pressure in front of cylinder 3, which was on the lee side of the vanes, was decreased, however, from $0.95q_o$ to $0.64q_o$. It is believed that with the addition of several other vanes in front of cylinder 3 the pressures could be redistributed to avoid any sharp local drops in pressure. A very effective means is therefore provided for increasing the pressure at any local hot cylinder simply by placing vanes in front of it and recovering the rotational energy at that point.

Tests were made with the spinner blower to determine the criticality of the blower blade settings. Changing the blade angle by 10° from 58° to 48° considerably decreased the pressure recovery on one side of the engine without changing it a great deal on the other side (fig. 13). This effect is explained by the fact that the blades, which were moving downward on the right-hand side of the engine (looking forward), were stalled and large changes in their blade angle did not greatly affect their lift. The blades on the left-hand side of the engine moving upward were operating in a linear portion of the lift curve and their decrease in lift was proportional to the change in angle. The difference in angles on the upgoing and the downgoing blades was due to the angle of attack of the nacelle.

Measurements were not made of the power input to the blowers; calculations indicate that the power consumption is low in proportion to the engine power even for the case in which the blades are stalled.

CONCLUDING REMARKS

Blowers operating at propeller speeds offer the possibility of substantial improvement in the pressures ahead of the cylinders in an air-cooled engine. In particular, it seems possible to increase the pressure locally in front of a hot cylinder by recovering the rotational velocities behind the fan as pressure at any desired point. The blowers, in effect, operate as a more efficient type of propeller cuff and in many cases may provide considerably more pressure boost than is available by means of a cuff. Structurally, the blowers appear to offer no large problems and provide a method of improving the cooling of hot engines without requiring major changes in the cowling design.

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REFERENCES

1. DeFrance, Smith J.: The N.A.C.A. Full-Scale Wind Tunnel. Rep. No. 459, NACA, 1933.

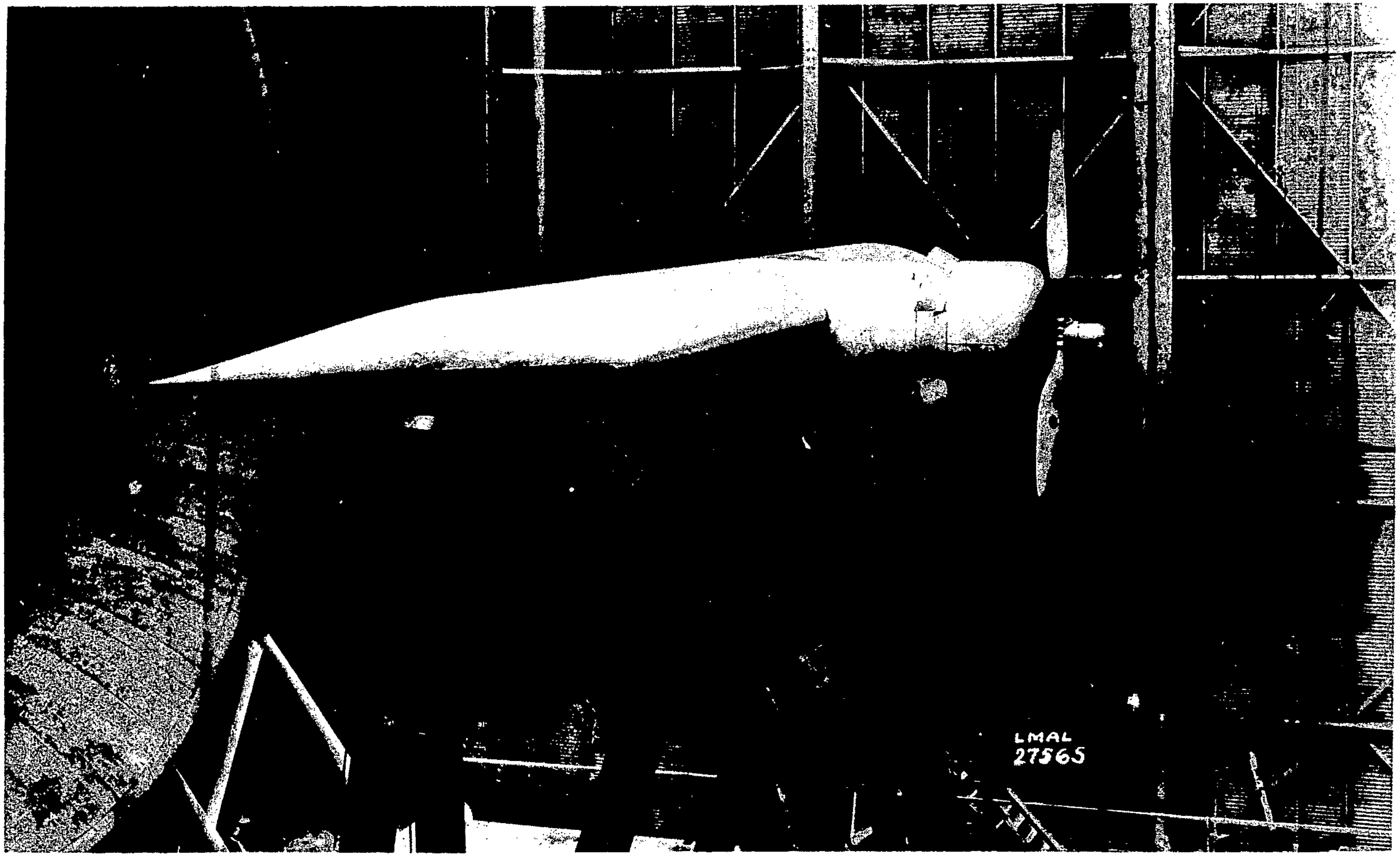

Figure 1.- Wing-nacelle installation in the full-scale wind tunnel.

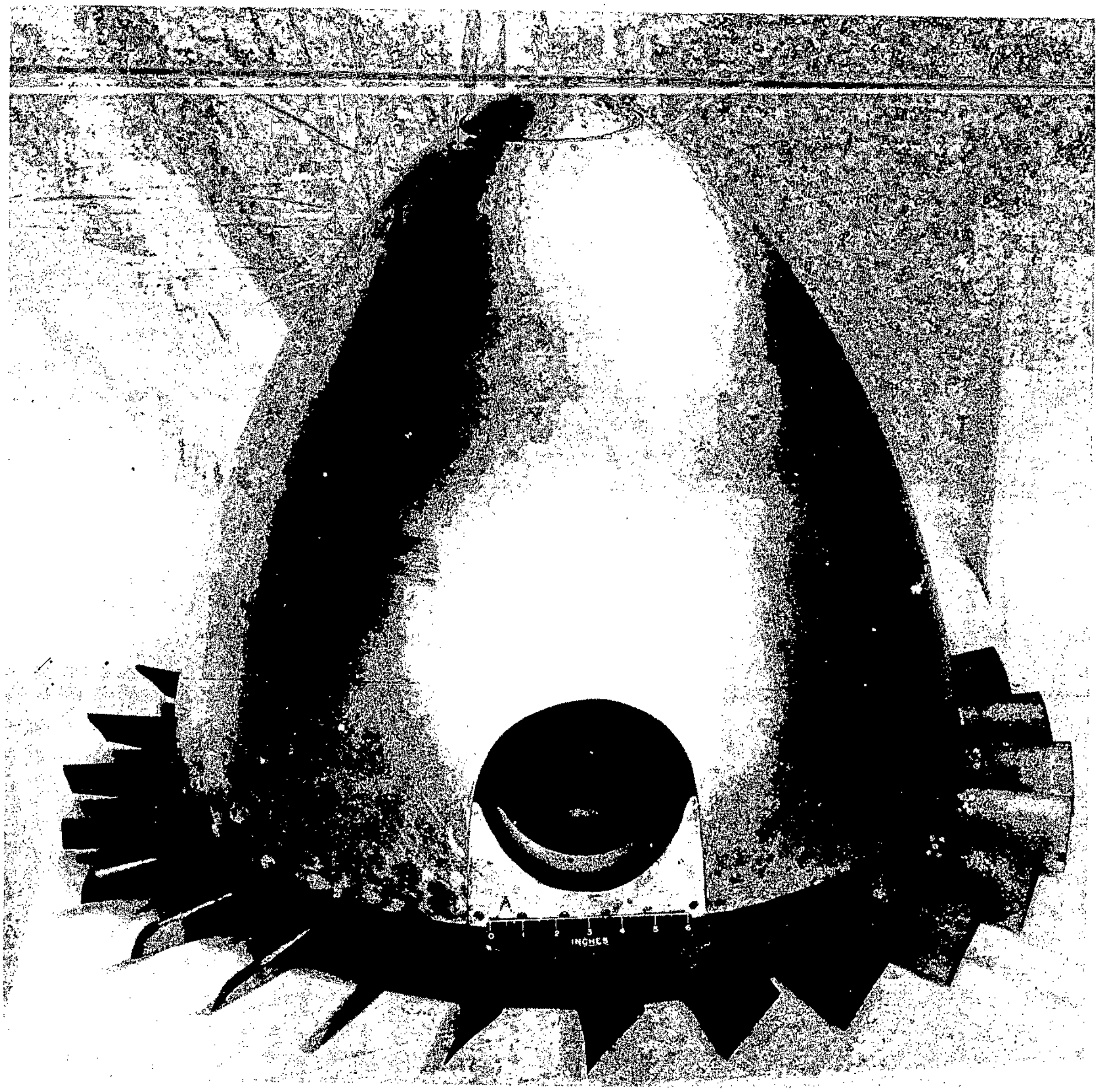

Figure 2.- Spinner blower.

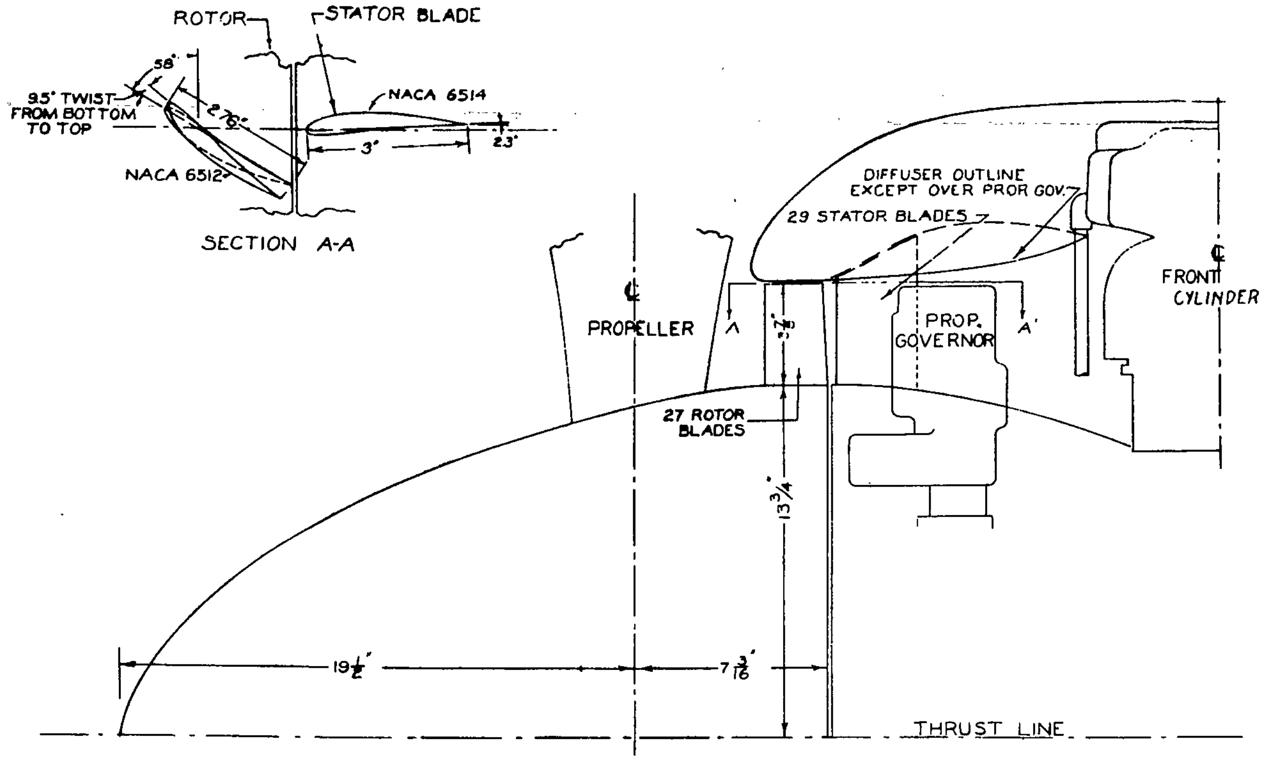

FIGURE 3.- SPINNER BLOWER INSTALLATION WITH STATOR VANES.

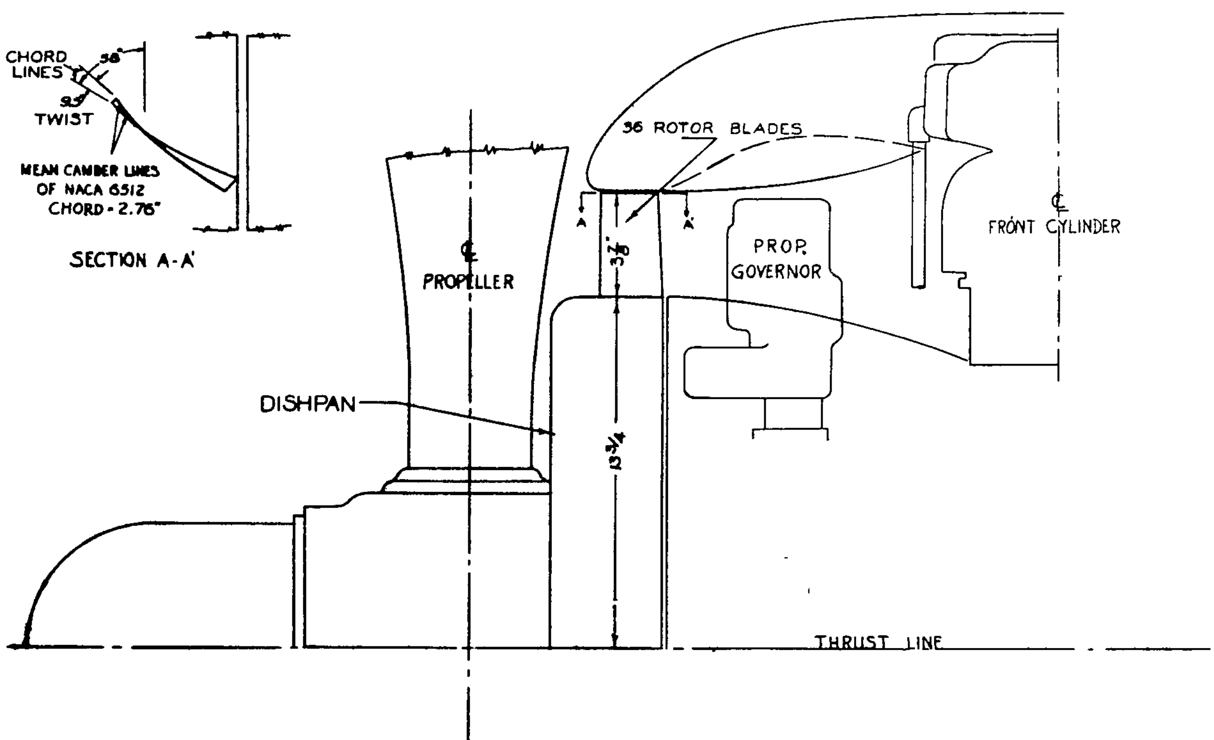

FIGURE 6.- DISHPAN BLOWER INSTALLATION.

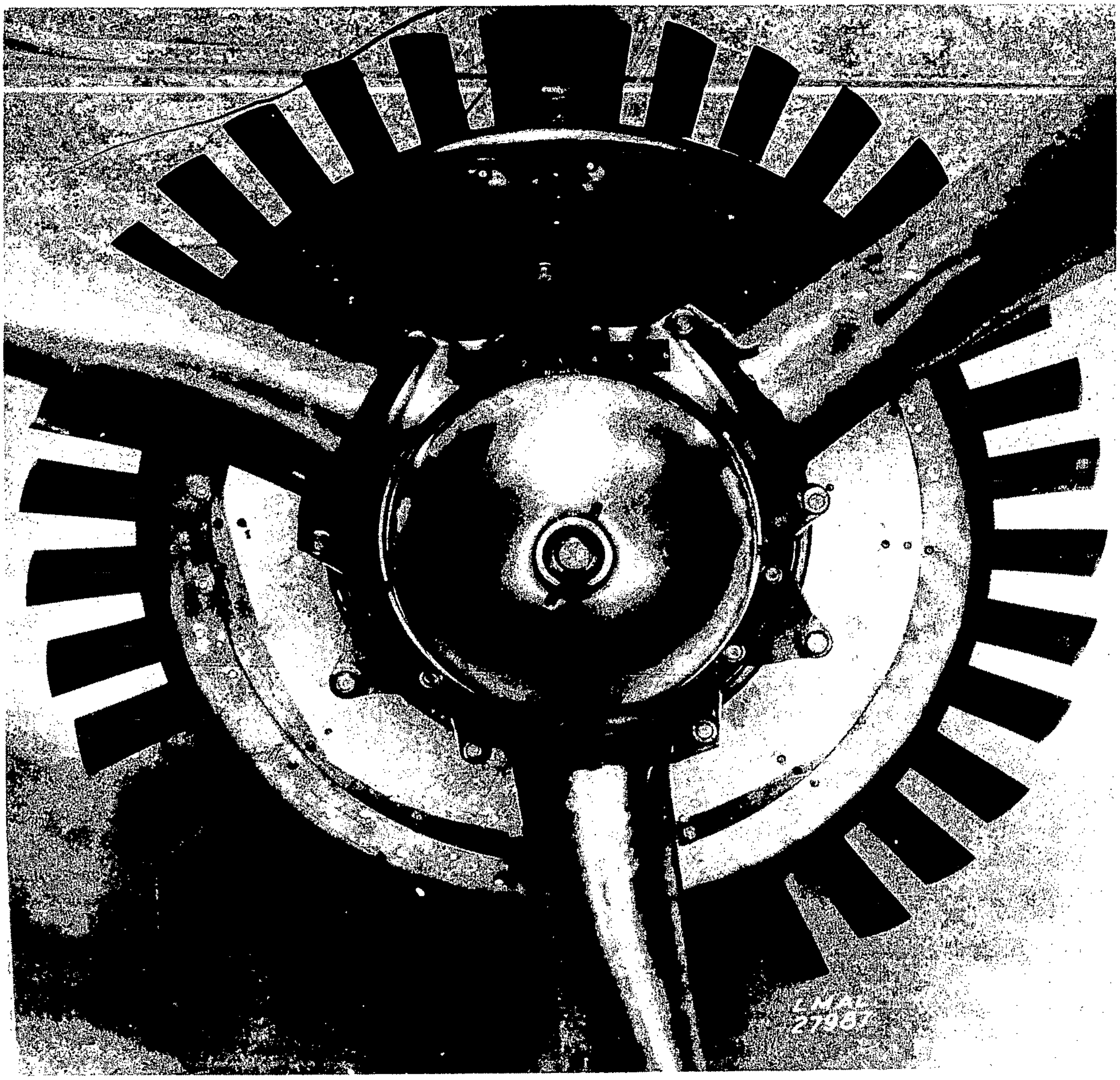

Figure 4.-Dishpan blower, front view.

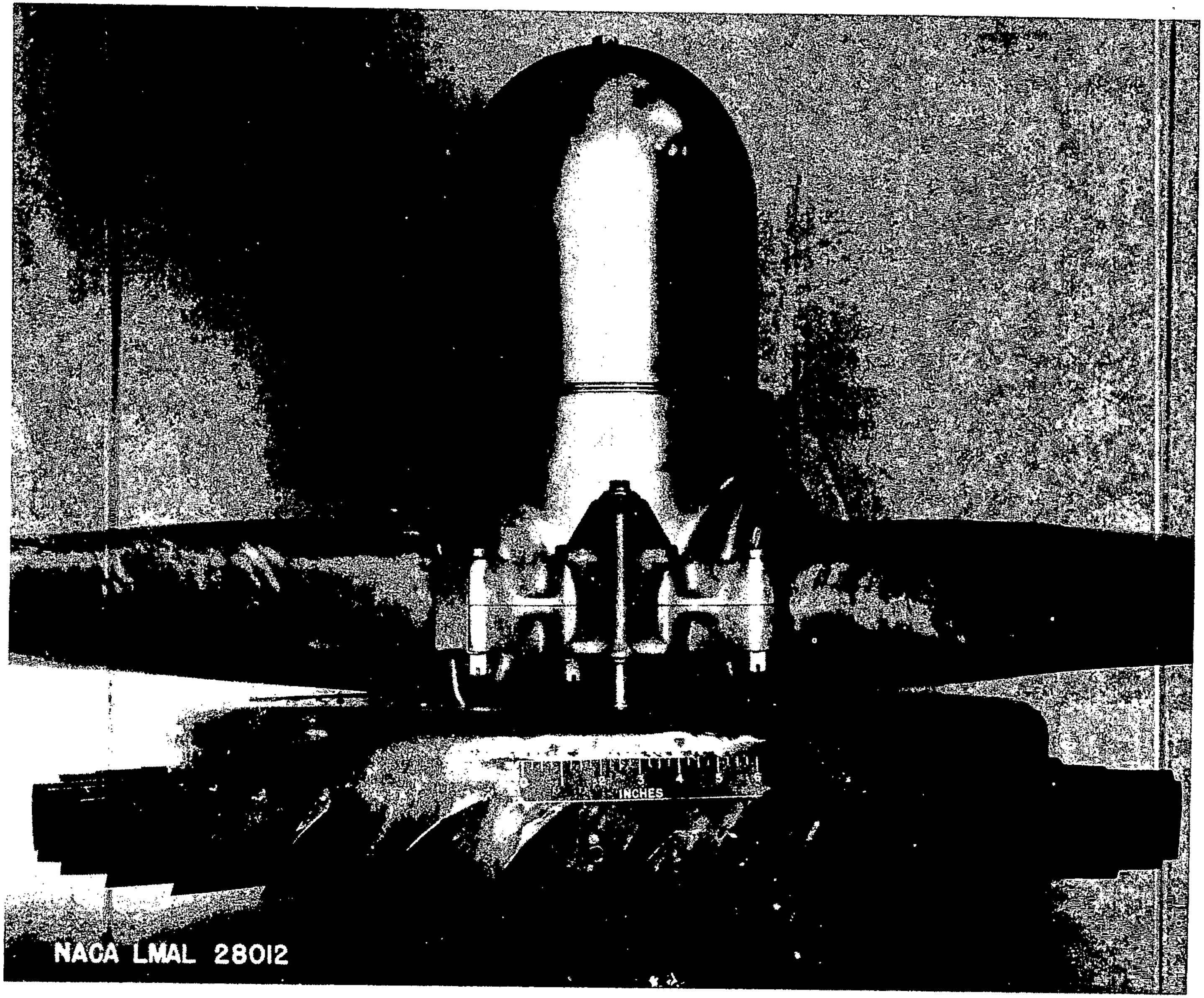

Figure 5.-Dishpan blower, side view.

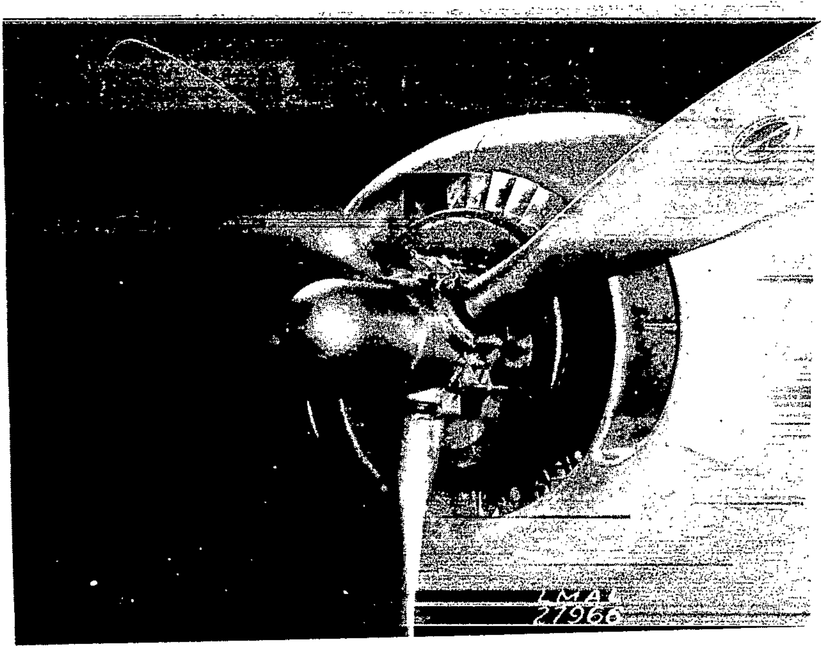

Figure 7.-Dishpan blower mounted on nacelle.

Figure 8.-Stator vanes used with dishpan blow

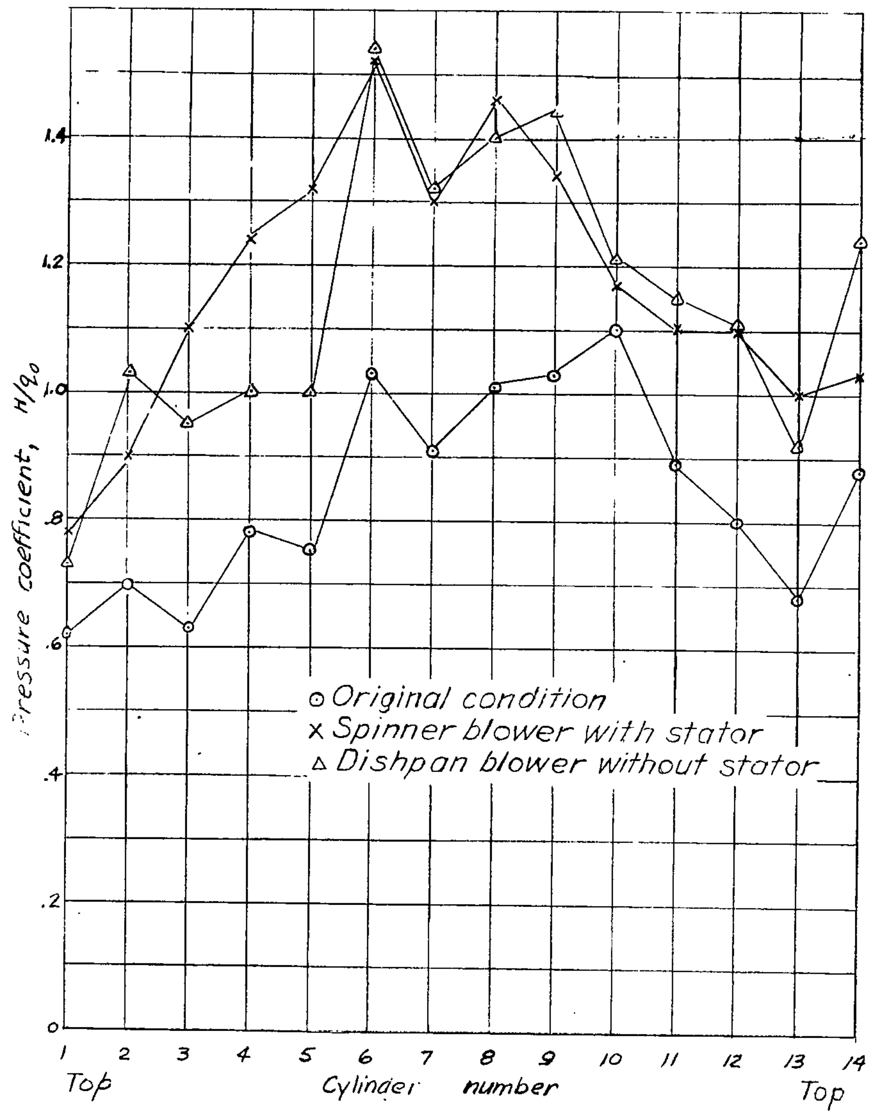

Figure 9. - Front-head baffle pressure with spinner and dishpan blowers in the climb condition.

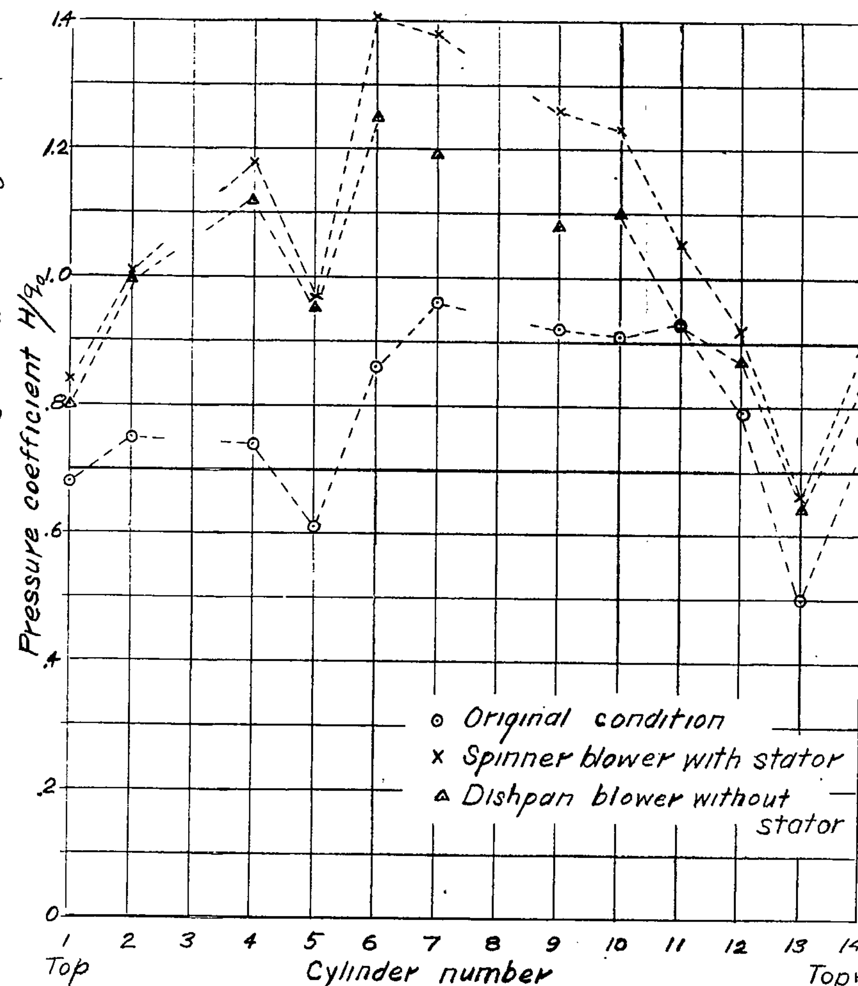

Figure 10. - Front-barrel baffle pressure with spinner and dishpan blower in the climb condition.

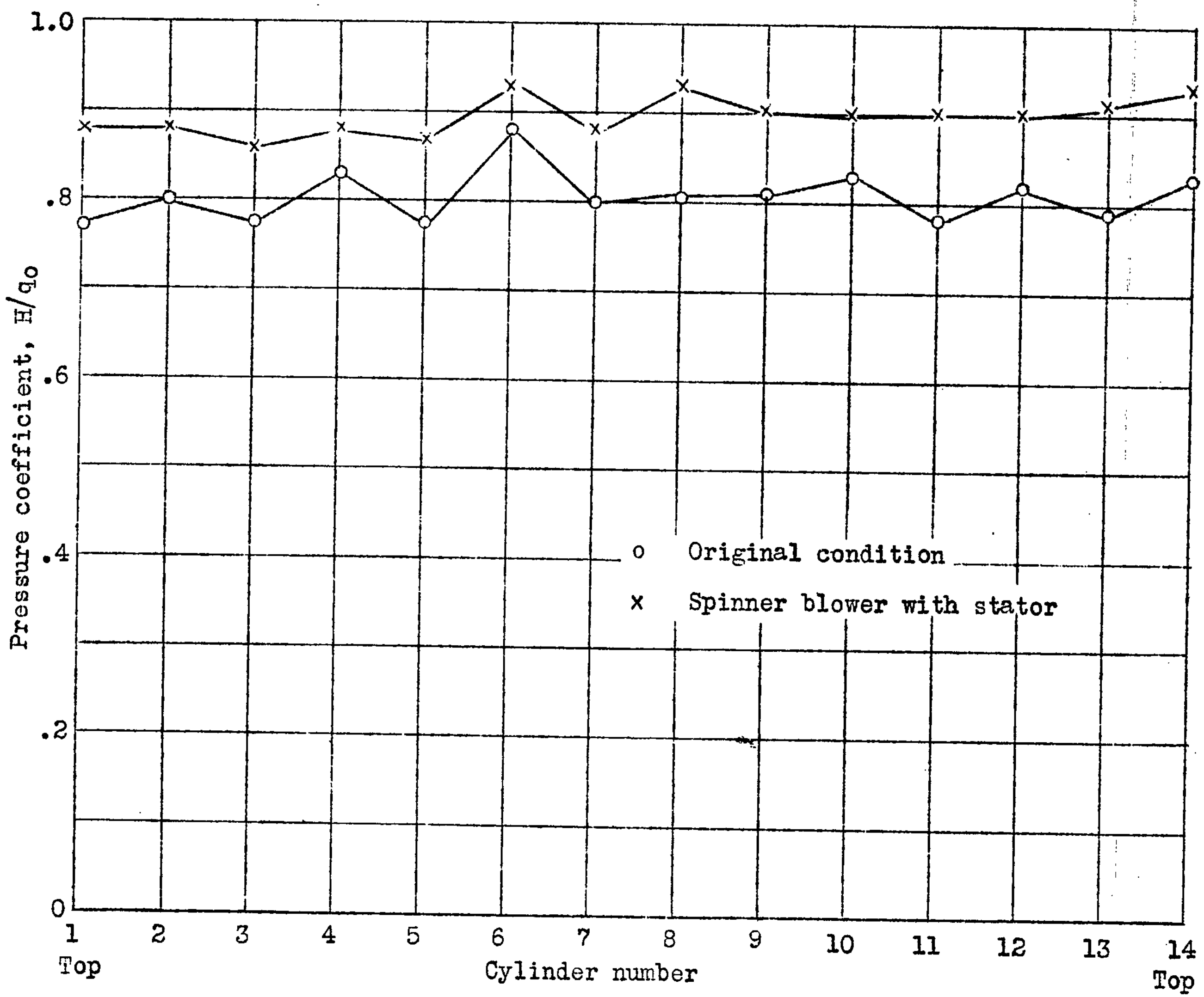

Figure 11.- Front-head baffle pressure with spinner blower in high-speed condition.

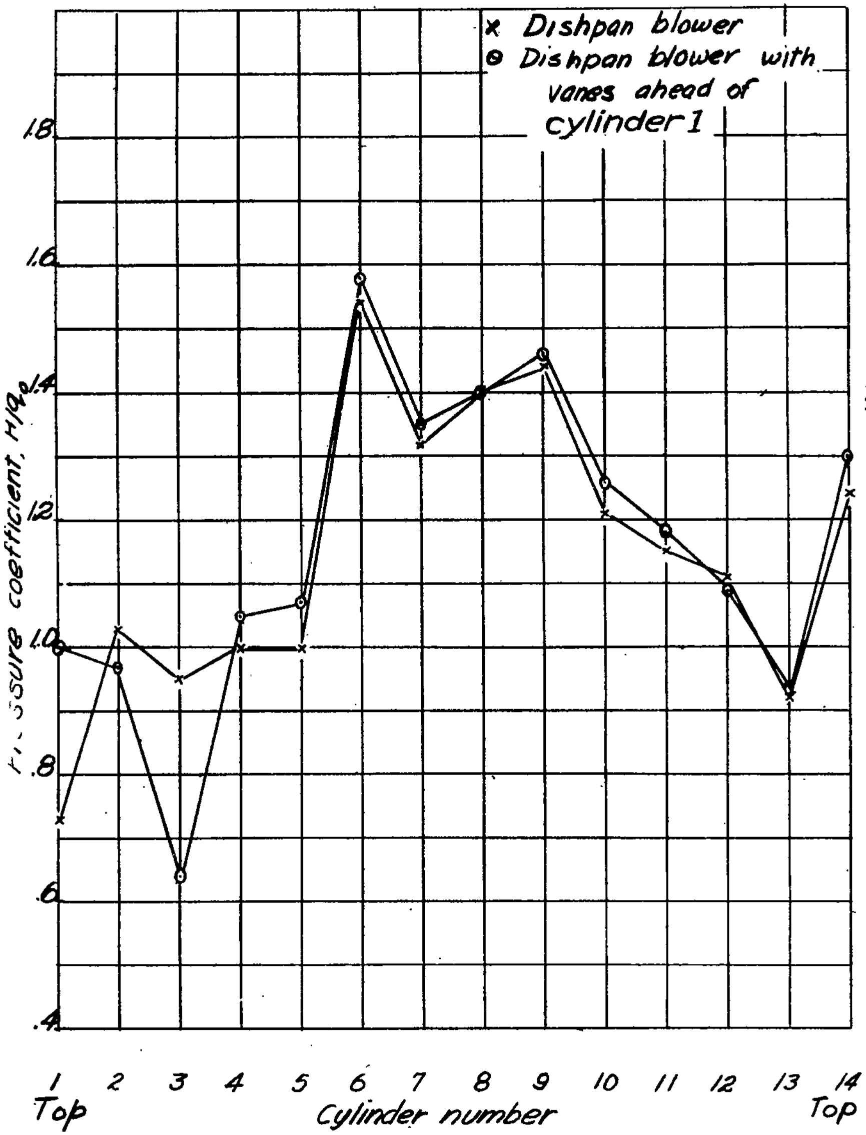

Figure 12. - Front-head baffle pressure with dishpan blower and vanes ahead of cylinder No. 1; climb condition.

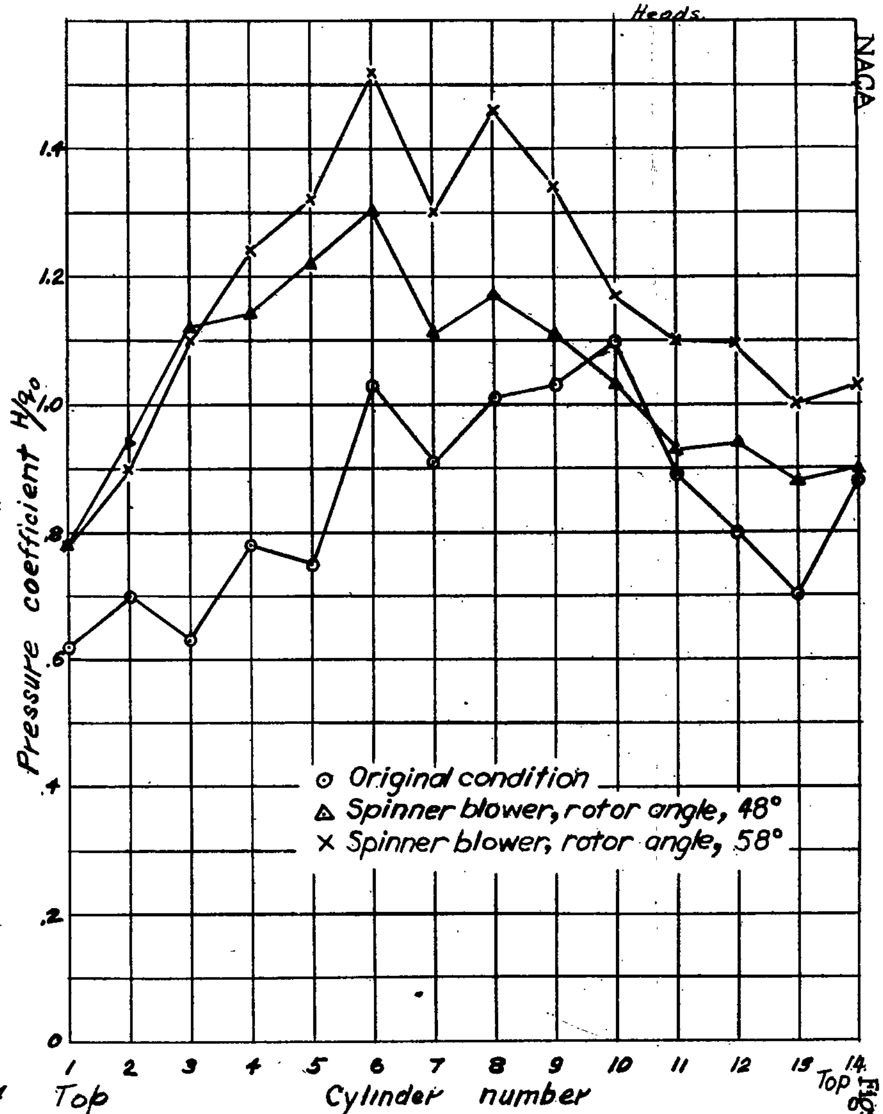

Figure 13. - Head baffle pressures with spinner blower at two rotor angles; climb condition.

Figs. 12,13